Introduction to the Theory of Constraints (TOC) & Critical Chain Project Management (CCPM)

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Principles of the Theory Of Constraints (TOC)

(aka Synchronous Manufacturing)

The Action You're Proposing:

--Will It Increase "Throughput"?

--Will It Decrease Inventory?

--Will It Decrease Operating Expense?

-Goldratt-

hput: not moving items, but "Sales", i.e. Finished product the customer

Business Rationale for Theory of Constraints (TOC)

Making Product ≠ Making $ *If You didn't Sell it!*

People Working ≠ Making $ *Until You Sell what they worked on!*

Manufacturing Goals

- Throughput (Sales) ↑
- Inventory & WIP ↓
- Operational Expense ↓

Simultaneously

Result In:

- NET Profit ↑
- ROI ↑
- Cash Flow ↑

n this TOC context, "Sales" = Revenue from customers Minus Vendo

THEORY OF CONSTRAINTS (TOC) PROCESS

1. **IDENTIFY THE CONSTRAINT**
   (identify capacity constraints, bottlenecks)

2. **EXPLOIT THE SYSTEM CONSTRAINT**
   (utilize & protect the bottlenecks)

3. **SUBORDINATE ALL OTHER RESOURCES TO THE CONSTRAINT**
   (utilize non-bottlenecks only to keep pace with bottleneck flows)

4. **ELEVATE THE SYSTEM CONSTRAINT**
   (reduce load, improve capacity & *reduce* variability of existing bottlenecks)

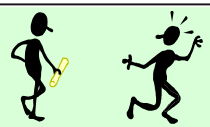
5. **RETURN TO STEP 1**

Sources: The Goal, by Goldratt and Cox
Critical Chain, by Goldratt

Some Highlights of TOC From “The Goal”

"SUM OF THE LOCAL OPTIMUMS $\neq$ GLOBAL OPTIMUM"

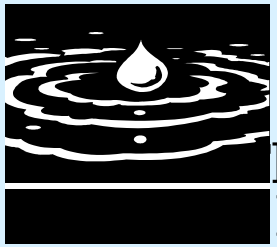
- BALANCE FLOW NOT CAPACITY
- BOTTLENECKS GOVERN BOTH THROUGHPUT AND INVENTORIES
- AN HOUR LOST AT A BOTTLENECK IS AN HOUR LOST FOR THE ENTIRE SYSTEM
- AN HOUR SAVED AT A NON-BOTTLENECK IS A MIRAGE
  - THE POTENTIAL OF A NON-BOTTLENECK IS NOT DETERMINED BY ITSELF BUT BY THE BOTTLENECKS
- IF YOU DON'T NEED A PART, DON'T MAKE IT. IT IS OK TO LET NON-BOTTLENECKS SIT IDLE.
- NEVER LET BOTTLENECKS SIT IDLE



"BOTTLENECKS PACE THE PLANT"

1. The output of upstream operations control the output of downstream operations.

2. The cycle times of all work centers varies -- this variability spreads through all downstream operations.



Therefore:

he maximum deviation of a preceding operation become the starting point of a subsequent operation.

Or:

1. Work Centers with excess capacity cannot work on parts they cannot get.

2. Bottlenecks cannot work on additional parts when they are already at 100% capacity.

3. Fluctuations in bottleneck outputs only make things worse.

A	→	B	→	Output
1 per hr	→	100 per hr	→	?
100 per hr	→	1 per hr	→	?

Bottlenecks can also be created by poor management **policies**:

. We need to Offshore Outsource: our labor: $15/hour, theirs: $0.5/hr

(Really? What about the time, costs of packaging & transportation, and Time
Sales lost when outsourced items are Unavailable, Delayed, and/or Bad?)

. We are to use our "5 Ms" at near-full capacity, that's Efficient

(BUT how long will they run Properly at that level? Are they working the
most important tasks? What do you do when you need More capacity?)

. Large Work in Process and Finished Goods inventories are Good, they show as Assets on the Accounting sheets

(BUT what are they Costing you, until the finished items are actually Bought?)

. Large Batches are Good, if we get a few bad items we'll recover

(BUT what do you do while waiting for Batches? What if Most items are bad?)

. If each step produces an Average of 10 items/hr, so will the Plant

(Really? What is the Spread? Don't dependent steps usually Amplify problems

. Improve (a) step's Efficiency, Whole Process gets better

(Really? What if That step was Not the "weakest link" in the Process "chain"?)

Note: Items B-F are metrics described in "The Goal" by Goldratt & Cox

"Inventory is the Root of All Evil"

T. Ohno (Toyota)
E. Goldratt

Always work on reducing inventory through:

1) **Reducing operations set-up time**
2) **Reducing cycle time and its variability**
3) **Reducing vendor variability in terms of quality, delivery times and delivery amounts**
4) **Do not make unnecessary parts -- even if people and machines sit idle**

DRUM — BUFFER — ROPE

DRUM: Paces the plant (bottlenecks)

BUFFER: Inventory protection for bottlenecks to ensure no stoppages

ROPE: Ties everything together; material releases and assembly schedules that reflect bottleneck constraints

THEORY OF CONSTRAINTS (TOC) PROCESS

(As Described In "The Goal" and "Critical Chain")

1. IDENTIFY THE CONSTRAINT

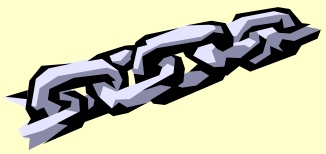
2. EXPLOIT THE SYSTEM CONSTRAINT

   --CRITICAL CHAIN PROJECT MANAGEMENT

3. SUBORDINATE ALL OTHER RESOURCES TO THE CONSTRAINT

4. ELEVATE THE SYSTEM CONSTRAINT

5. RETURN TO STEP 1



Some Project Time & Resource Concerns

- Working to multiple lists
- Not enough resources, yet shared across all projects
- Managers keep changing priorities, lose time taking people off jobs then restarting jobs later (multi-tasking)
- Difficult getting the right people at the right time assigned to the right tasks

Source: NAVSEA, Pearl Harbor Naval Shipyard & IMF

Some Human Factors

- **People perform consistently with the way they are being measured--*Even if the metric is not appropriate***
- **Jobs usually start later rather than earlier**

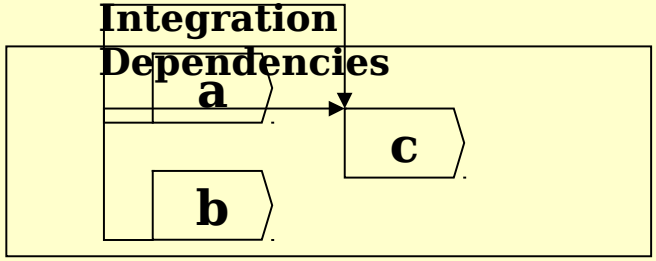
  -- Don't start early, or you'll just get to do it Over-right?
- **When work is completed early, there's a tendency to enhance it—*So little time is saved***
- **What can go wrong will . . . (Murphy)**

  ---Don't most folk add time to schedule to account for this?
- **Often have no structured methodology to lower schedule risk for tasks in progress**

Source: NAVSEA, Pearl Harbor Naval Shipyard & IMF

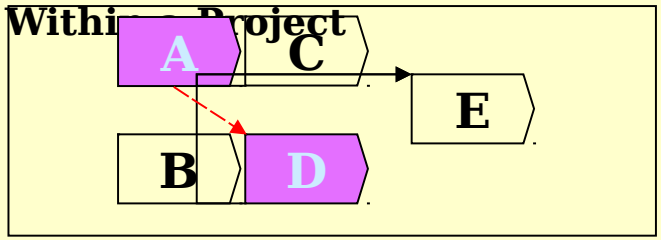
UNCERTAINTY UNLEASHES A CASCADE EFFECT

Integration Dependencies



- **Delays: “c” is delayed if either “a” or “b” is late**
- **Gains: Even if “a” or “b” finishes early, “c” cannot started**

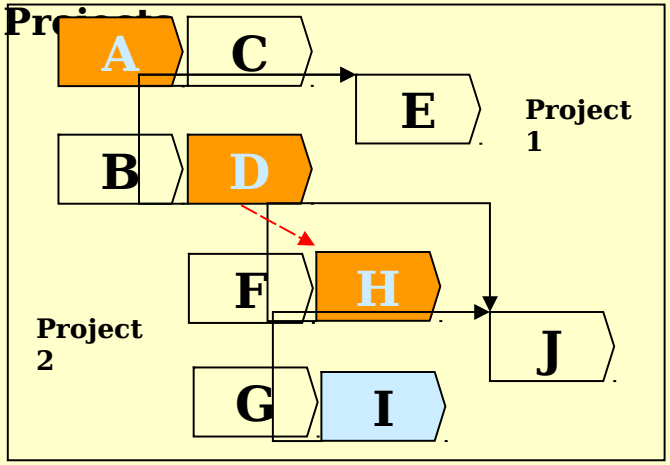
Resource Dependencies Within a Project



A & D are done by the same resource

- **Delays: If A is late, not only C but also D gets delayed**
- **Gains: Even if A finishes early, resource cannot start D as has to wait for B to finish**

Resource Dependencies Across Projects



D & H are done by the same resource

- **Delays: If D on Project 1 is late, H on Project 2 also gets delayed as resource is stuck on D**
- **Gains: Even if D finishes early, resource cannot start H as has to**

Cascade Effect

Delays multiply: every small delay propagates, within and across projects

Gains don’t add up: even if many tasks finish early, projects still cannot finish early

Source: NAVSEA Pearl Harbor Naval Shipyard & IMF

CRITICAL CHAIN PROJECT MANAGEMENT (CCPM)

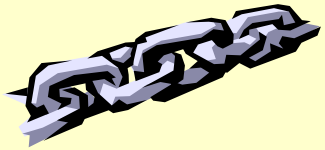
Critical Chain - longest chain of dependent tasks

Dependent through finish-to-start connections

OR

Resource dependency

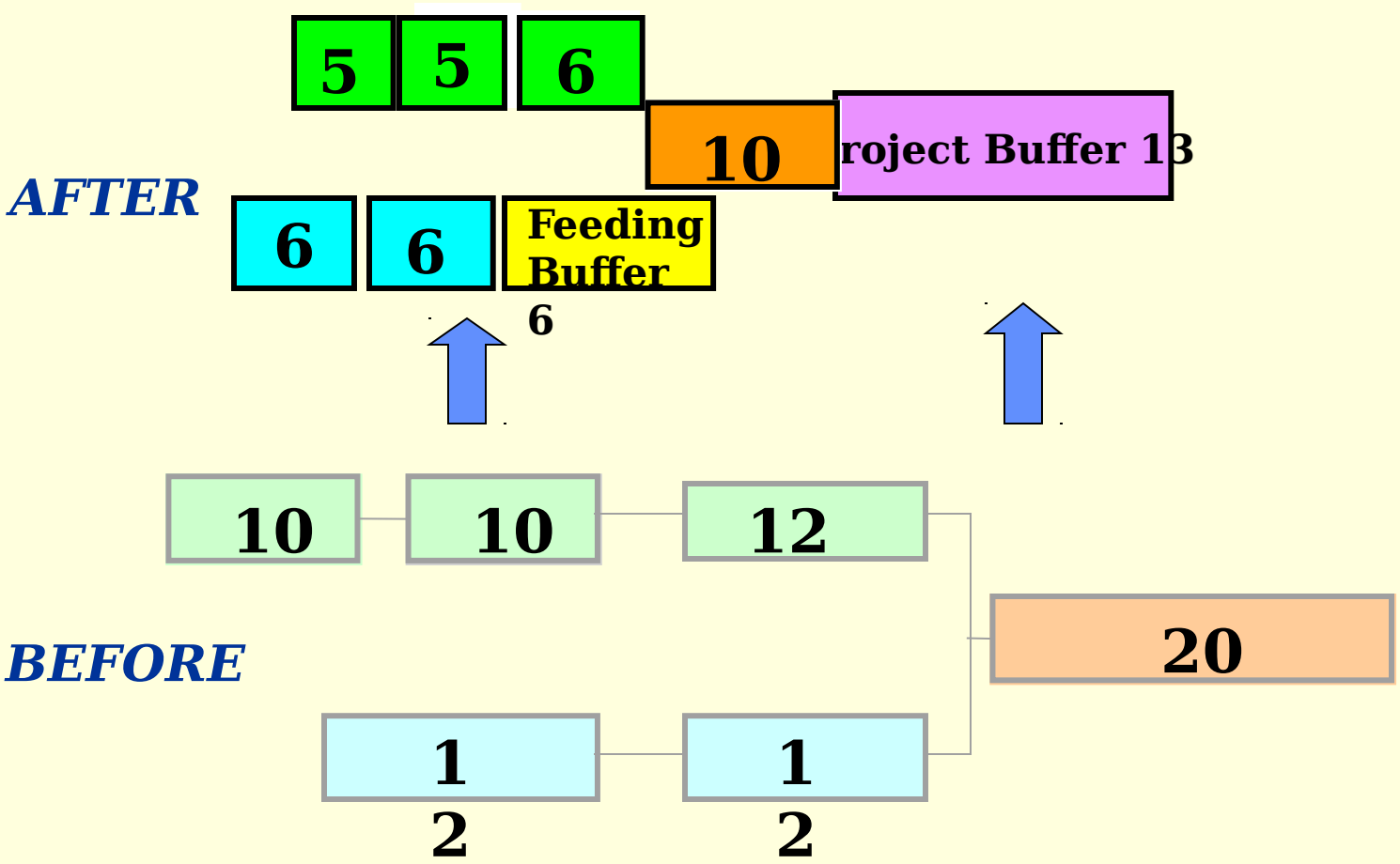
CCPM provides a step by step job plan of action, based on:



-- Aggressive job time estimates
-- Precedence network
-- Resource loading and teaming
-- Human nature
-- Pooled safety
-- Buffer management

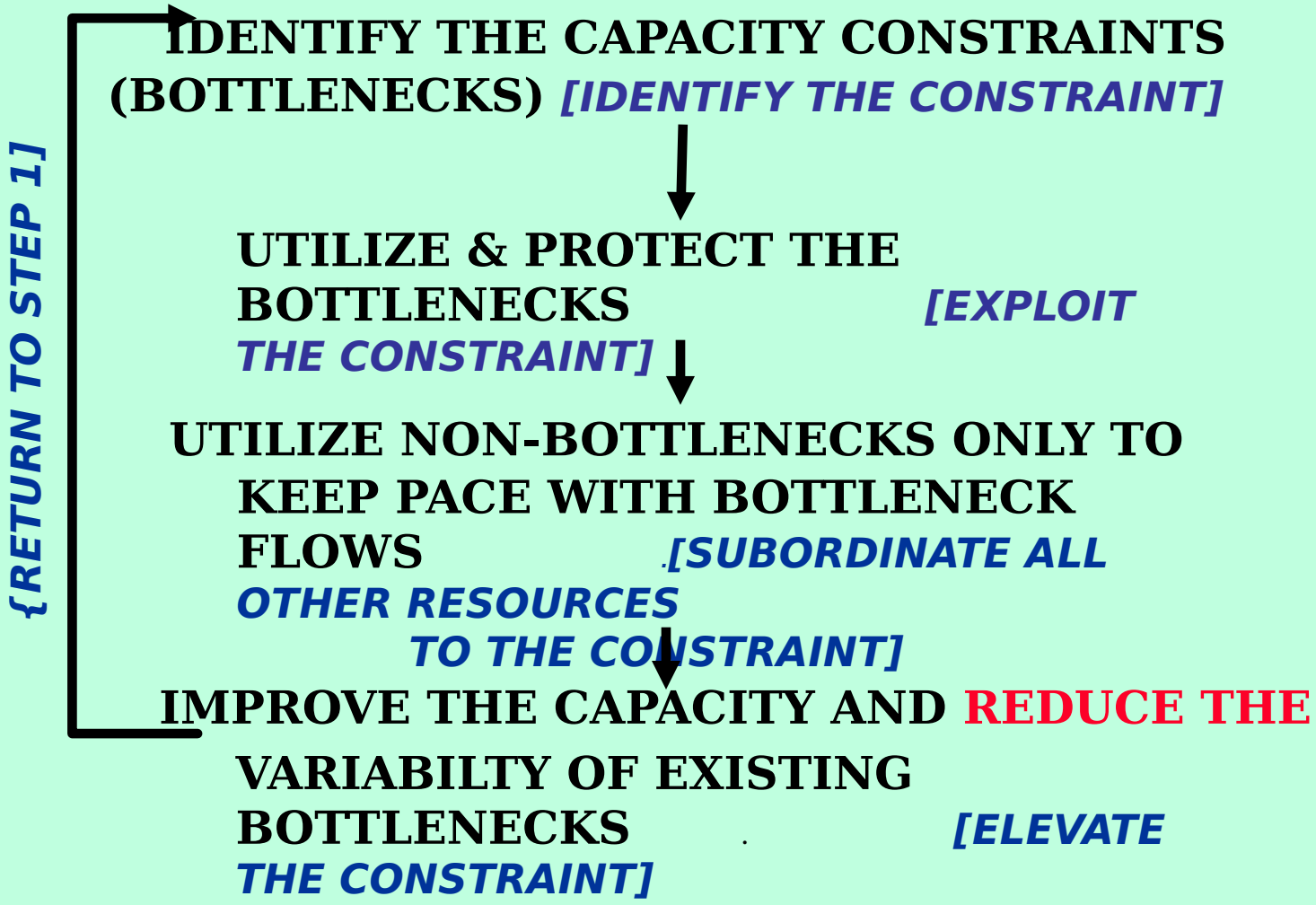
Aggressive Job Time Estimates, Pooled Safety and Buffer Management

Task duration estimates and buffer placement



Source: NAVSEA, Pearl Harbor Naval Shipyard & IMF

The Theory of Constraints (TOC) Process


IDENTIFY THE CAPACITY CONSTRAINTS (BOTTLENECKS) [IDENTIFY THE CONSTRAINT]
UTILIZE & PROTECT THE BOTTLENECKS [EXPLOIT THE CONSTRAINT]
UTILIZE NON-BOTTLENECKS ONLY TO KEEP PACE WITH BOTTLENECK FLOWS [SUBORDINATE ALL OTHER RESOURCES TO THE CONSTRAINT]
IMPROVE THE CAPACITY AND REDUCE THE VARIABILTY OF EXISTING BOTTLENECKS [ELEVATE THE CONSTRAINT]
{RETURN TO STEP 1]

ALSO Remember: TOC applies to ALL Activities– Not just Mfg